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Factors Affecting Gingival Excess, Altered Passive Eruption and Recession in the Mandibular Anterior and Premolar Sites

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

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Abstract

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By William F Bohlen, D.M.D.

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AIM: The aim of this study was to determine the factors affecting gingival excess, altered passive eruption and recession. **METHODS**: 100 subjects were examined clinically and models of their mandible were fabricated. Demographic, periodontal and cast measurements were recorded for each subject. Measurements were made on casts with digital calipers and included clinical crown length, clinical crown width, papillary height and gingival width. The W:L ratio was calculated and the proportion compared to the maxillary arch ideal of .80. Values greater than .80 were used as a cutoff point for defining gingival excess. Measures of periodontal health were also examined and included probing depths, clinical attachment loss and bleeding on probing. Other patient variables examined were history of orthodontics, presence of occlusal and incisal wear, presence of parafunctional habits, subjective appearance of gummy smile and biotype. **RESULTS**: The mean W:L ratio was found to be 79.6 %. Tooth type ($p<0.001$), gender ($p<0.0237$) and biotype ($p<0.0081$) were found to significantly contribute to a W:L ratio >.80. There was a significant correlation between the subjective appearance of gingival excess and the W:L ratio, regardless of biotype. There was no association between recession and gingival excess. **CONCLUSION:** Subjectively**,** 17% of the study subjects had gingival excess. When the author (WB) made the determination that gingival excess was present, there was a significant increase in the W:L ratio for all teeth, regardless of biotype versus teeth without the presence of gingival excess. Proposed ideal W:L ratios for the mandibular anterior teeth from the second premolar to central incisor are listed in Table 11.

Introduction

One of the detractors from optimal smile esthetics is a “gummy smile”. The presence of a gummy smile is due to factors predominately related to the maxillary arch, since it is the more visible of the arches in a smile in most patients. In a “gummy smile,” a patient shows excess maxillary gingival tissue for a variety of factors including vertical maxillary excess gingival tissue, incisor overeruption of maxillary incisor teeth, gingival overgrowth, short or hyper-mobile upper lip (high smile line) and altered passive eruption[1.] For this reason, studies of smile esthetics have focused on the maxillary arch. The same factors have not been studied in the mandibular arch.

This study will examine the variables that may contribute to excessive amounts or a lack of gingival tissue in the mandible. Among these variables are the gingival widths of keratinized tissue, gingival biotype and altered passive eruption. By examining how these variables interact with each other, the appearance of excess gingival display in the mandibular arch and overall gingival health may be investigated.

One of the most important factors related to excess gingival tissue is altered passive eruption (APE). Altered passive eruption refers to an aberration in the eruption pattern of teeth that results in excessive gingival display. Tjan[15] found the prevalence of APE to be present in 7% of men and 14% of women in both maxillary and mandibular arches, while Volchansky[16] found the prevalence in both arches to be around 12% in a population with a mean age of 24.2 years of age. APE was first described by Gottlieb and Orban[17] and it involves migration of the gingival apparatus apically. Coslet[18] developed a classification system for APE of both the maxilla and mandible that defined two types of passive eruption. The first form, Type 1, is defined as location of the gingival margin at an incisal or occlusal position relative to the CEJ, with the mucogingival junction at a level apical to the alveolar crest. Type 2 is defined by the presence of a normal gingival margin to mucogingival junction width with the mucogingival junction located at or near the CEJ. These two groups are then subdivided into A and B subtypes. The A subtype, delayed passive eruption, is defined as a "normal" CEJ to alveolar crest distance of 1.5-2 mm. The B subtype, arrested passive eruption, is defined as having an alveolar crest at the level of the CEJ. In the delayed variety, a normal "biological width" is established according to the mean dimensions described by Gargiulo et al.[19], of .69 mm for sulcus depth, .97 mm for epithelial attachment and 1.07 mm for connective tissue attachment. In the arrested form, there is a junctional epithelial attachment on enamel, which can result in the appearance of shorter clinical crowns. For that reason the length and width of the clinical crown have been used as a possible predictor of altered passive eruption.

Wheeler[21] described the average width of crown, width of cervical diameter, length of root, and length of crown measurements of extracted mandibular incisors, canines and premolars. The average length of the crown was 9 mm for a mandibular central incisor**,** 9.5 mm for a lateral incisor, and 11 mm for a canine. The first premolar was 8.5 mm and the second premolar was 8 mm. The crown widths at the widest point were 5 mm for the mandibular central incisor, 5.5 mm for the lateral incisor, 7 mm for the canine, 7 mm for the first premolar and 7.5 mm for the second premolar. It should be noted that these values represent the length and width of the enamel on teeth, but are not measures of the visible clinical crown in a mouth. Due to the position of the attached gingival tissue in a normal case, the actual clinical crown in the normal case would be shorter than the length of the enamel by dimensions of the epithelial attachment plus the sulcus depth which add to approximately 1.66 mm, according to Gargiulo[19]. In the case of altered passive eruption, the clinical crown would be further shortened, providing a possible measure of the occurrence of altered passive eruption.

The appearance of gingival excess can be created by factors other than altered passive eruption. The width of the gingival tissue itself may be unusually large. Gingival width or the measurement from the free gingival margin to the mucogingival junction (MGJ), provides a measure of the amount of keratinized tissue apical to the tooth. The gingival width is greater in males than females[3] and increases as patient's age and teeth continue to erupt, resulting in decreased probing depths[4]. The gingival width also increases as a result of continual apical deposition of cementum as a compensatory response to incisal wear[5]. Bowers[6] found that the average width ranges from 1-9 mm and that, within the mandible, the canine and premolars tend to have less keratinized tissue width than the incisors. This investigation sought to answer the question of whether, or not, gingival width has an effect on APE or gingival health.

While excess gingival tissue may be viewed as a negative factor to esthetic appearance, it may also have a positive effect on gingival health. One of the indicators of gingival health in the mandible is the absence of recession. Kennedy and Bird[7] followed 32 patients with areas of recession and no keratinized tissue over 6 years and found that with adequate plaque control, they were able to prevent further attachment loss. Wennstrom[8] used beagle dogs to show that if all keratinized tissue was removed and adequate plaque control was achieved, further recession could be prevented over 4 months post-operatively. In contrast to these findings, Lang and Loe[9] felt that 2 mm of keratinized tissue was necessary for health and resistance to recession, regardless of level of oral hygiene. For that reason the amount of keratinized tissue present, on a tooth by tooth basis, will be investigated in order to ascertain its effect on gingival health in terms of resistance to recession or contribution to APE. The amount of keratinized tissue present is independent of the location of the gingival margin in relation to the crown. There may be certain instances where there is keratinized tissue present in an area of recession and vice versa. Alternatively, there may also be areas with APE and differences in amount of attached tissue.

Gingival thickness is another variable that has been associated with both excess gingival tissue (APE) and gingival health. Goaslind[10] found that the average mean thickness of keratinized gingiva was 1.44 mm with the average free gingival thickness measuring 1.56

and the attached gingiva measuring 1.25 mm. Muller[11] examined the thickness of mandibular gingiva in a population of forty 19 to 30 year-old males and females and found that females had significantly thinner gingiva than males. Also, on average, the thickness of the gingival tissue on the buccal surface of the mandibular central incisor was .7 mm thick and the mandibular lateral tissue was .9 mm thick, indicating intra-arch variation in the thickness. It is generally accepted that when comparing thick versus thin gingiva, the thicker gingiva is better able to resist insult from plaque biofilm and therefore less likely to break down, resulting in decreased gingival width and likelihood of recession. In both human and animal studies, gingival thickness has been shown to be critical in the prevention of mandibular incisor recession as a result of buccal tooth movement during orthodontic treatment. Melsen[12] found that the only variable associated with risk for gingival recession in mandibular incisors subjected to orthodontic tooth movement was thin tissue. Wennstrom's[13] monkey study, in which maxillary teeth with varying widths and thicknesses of keratinized tissue were subjected to buccal orthodontic forces over 3-4 months, showed that the most important factors for recession development were plaque presence and thin tissue. Width of keratinized tissue had no effect on the development of recession. The data therefore shows that thick gingiva is better suited to resist the development of recession.

The effect of biotype on excessive gingival tissue and/or APE will also be examined in this study. Biotype is a genetically determined trait and it can be thin or thick. Most often it refers to the gingiva, but it also includes the underlying bone. The alveolar bone and gingiva do not necessarily have the same biotype. De Rouck[14] conducted a study in which gingival biotype was correlated with varying degrees of gummy smile. The presence of APE was determined by examining the ratio of width to length for the maxillary central incisor. A larger number indicated a “gummier” smile. Biotype was categorized by documenting the transparency of the periodontal probe through the gingiva. Thinner biotypes allowed the probe to be easily visible, while thicker biotypes obscured the appearance of the probe. De Rouck examined maxillary central incisors in a group of 50 males and 50 females and then calculated the crown width to length ratio for all of the teeth, correlated this proportion with the biotype, and found that there were three clearly defined groups. Group 1 (n=37) had a crown width to length ratio of .79 and a clear, thin biotype. Of these 37, 28 were female. The second group (n=34) had a .77 crown width to length ratio and thick, clear biotype. The third group (n=29) had a crown width to length ratio of .88 with a thick gingival biotype. These results suggest that a thick biotype can be a contributor to gingival excess and therefore offer some protection from gingival recession. The effect of biotype on gingival excess in the mandible will be investigated for the first time in this study.

The primary purpose of this investigation is to determine the factors that contribute to gingival excess and recession. Secondary objectives are to correlate subjective appearance of gingival excess to width-to-length ratios and to establish "ideal" width-to-length ratios for the mandibular anterior teeth and premolars. By determining the variables associated with gingival excess and recession, prognostic value can be placed on them and future changes in gingival health may be more easily predicted.

Methods and Materials

One-hundred healthy, non-smoking adult subjects were recruited from the Virginia Commonwealth University School of Dentistry by e-mail notification and word of mouth to participate in the study. Participants were warned of any potential risks and were compensated for their time. No attempts were made to recruit patients specifically for the presence of altered passive eruption.

The inclusion criteria included subjects having all mandibular central incisors to second premolars with bilateral occlusal contacts. This eliminated the possibility of supraeruption presence that would lead to inaccurate crown length measurements. All of the subjects were older than 18 years old.

The exclusion criteria included pregnancy, active periodontal disease (BOP and CAL of 4 mm or greater), systemic conditions that could modify the progression or treatment of periodontal disease (e.g. Diabetes mellitus), history of periodontal surgery in the area being studied, missing teeth in recorded areas, history of drugs that could contribute to gingival overgrowth (anticonvulsants, calcium channel blockers, immunosuppressants), poor oral hygiene (evidence of gross supragingival plaque and calculus), current or past smoking (10 cigarettes or more per day) and previous mandibular esthetic crown-lengthening or gingival grafts.

Informed consent was obtained under a procedure approved by the Institutional Review Board (IRB**)** of Virginia Commonwealth University for research involving humans. IRB approval was obtained prior to the initiation of this investigation.

Periodontal Exam

A clinical examination was carried out by a periodontal clinician (WB) and data were recorded. Patients' self reported age, gender, and race were recorded. Periodontal conditions were measured with a standardized UNC probe from #20 to #29. The periodontal conditions measured included sulcus depth (SD), gingival index (GI)[12], plaque index (PI)[12] , clinical attachment levels (CAL) and bleeding on probing (BOP) and were recorded at three facial sites per tooth.

Cast Measurements

Subjects had impressions made of their mandibular arch with alginate, and stone models were fabricated. Measurements were made with a digital caliper and were made from teeth #20 thru #29 on dental stone models. The crown length was measured from the free gingival margin to the incisal or occlusal edge. The crown width was measured from the mesial height of contour to the distal height of contour. Papillary height was also recorded and was measured as a distance from a line drawn tangentially to the most apical portion of the gingival scallop to the papilla tip. The distance from the gingival scallop of the mandibular lateral incisor to the gingival esthetic line (GAL) was also documented. Gingival width was also measured as the distance from the free gingival margin to the mucogingival junction (MGJ). Gingival width was only measured on 85 of the casts because the MGJ was only discernible on 85 of the models. Clinical crown width-to-length ratio (W: L) was calculated from the average clinical crown length and average clinical crown width measurements of each tooth type. These measurements were compared to the ideal of .80 width-to-length ratio of maxillary teeth as previously reported by Konikoff[20] in the maxillary arch. Any measurement > .80 was considered to possibly have altered passive eruption. This .80 value was an arbitrary value because it has not been shown to have any value or relevance in the mandible. It was used as a baseline number because it has been shown in the maxilla in numerous studies to have relevance.

Subjective information was recorded and included history of orthodontic treatment, presence of parafunctional habit, presence of incisal or occlusal wear, overall appearance of mandibular gingival excess, biotype (measured according to De Rouck[14], by examining the straight buccal of the central incisors) and whether or not symmetry present between right and left sides was present.

The appearance of gingival excess was measured by evaluating the patients' mandibular teeth prior to the clinical exam. The appearance of gingival excess of the mandibular arch was a subjective determination and was recorded by (WB) as either present or absent.

Analysis

Descriptive analysis was performed for this study on variables pertaining to demographic data, presence of thick/thin biotype, all cast measurements of width and length, periodontal parameters (probing depths, clinical attachment levels, recession, mucogingival width, amount keratinized tissue) and percentage of patients with subjective appearance of gingival excess and their corresponding width-to-length ratios.

In order to determine the influence that variables such as biotype had on width-to-length ratio, logistic regression was performed with the arbitrary maxillary "ideal" of .80 width-to-length set as the response variable.

When the response variable was continuous, data were analyzed with repeated measures analysis of variance by tooth type to determine which variables were related to keratinized tissue and recession. Keratinized tissue and recession were the continuous response variables evaluated in this manner and the independent variables in the model were age, gender, race, whether or not the individual had orthodontic therapy, had occlusal wear or had the appearance of "gummy smile".

Repeated measure analysis of variance, logistic regression and Fisher's exact test were also performed in order to determine which variables were significantly related to presence of altered passive eruption and recession.

Results

One hundred dental students at the Virginia Commonwealth School of Dentistry were examined and models were taken of their mandibular arches according to the previously mentioned criteria. The subject population consisted of 39 females and 61 males with an average age of 25.91 years of age. Thirty-nine of the subjects reported a history of orthodontics and 67 subjects reported having a parafunctional habit (Table 1**).** Sixty of the subjects were recorded as having a thick biotype (Table 1).

When the individual tooth lengths were estimated**,** it was found that the average lengths for tooth types were 8.01 mm for mandibular central incisors, 8.24 mm for the lateral incisors, 9.45 mm for canines, 8.09 mm for first premolars and **7**.10 mm for second premolars. Average widths for the same teeth were 5.26 mm for the central incisors, 5.84 mm for the lateral incisors, 6.73 mm for the canines, 7.06 mm for the first premolars and 6.94 mm for the second premolars (Table 3).

When the width-to-length ratios were calculated, the values ranged from 67% for the mandibular central incisor to 99% for the mandibular second premolar (Table 3**)**. The findings of this study also indicate that the mean width-to-length ratio for the mandibular arch is 79.6%, which is consistent with the 80% arbitrary threshold that has been used in studies of the maxillary arch as a possible indicator of APE. When the width-to- length ratio was examined for individual teeth, it was found that 92% of mandibular second premolars had an 80% or greater width-to- length ratio, with a mean of 99% width-to-length ratio. In contrast, only 9% of mandibular centrals exhibited an 80% or greater width-to-length ratio with a mean value of 67% width-to- length ratio (Table 3).

When the association between width-to-length ratio and factors such as age, presence of occlusal wear, presence of parafunctional habits, history of orthodontics, gender, tooth type, race, symmetry and biotype were examined, only tooth type ($p<0.001$), gender ($p<0.0237$) and biotype ($p<0.0081$) were found to be significant (Table 4**)**. In regards to biotype, a thick biotype was significantly more likely to have a higher width-to-length ratio when compared to a thin biotype (84.89% W:L ratio for thick, 80.15% for thin)(Table 5.) For gender, females were significantly more likely to have a higher width-to-length ratio (84.77% W:L ratio) than males (80.27% W:L ratio) (Table 6). For tooth type, the mandibular second premolar was significantly more likely, when compared to the mean width-to-length ratio of 79.6%, to have a width-to-length ratio>.80 (102% W:L ratio) (Table 7**).** In regards to biotype, a thick biotype was significantly more likely to have altered passive eruption when compared to a thin biotype **(** 84.89% W:L ratio for thick, 80.15% for thin).

In order to determine how variables such as biotype might affect the average clinical length of the teeth, repeated measures of variance were performed**.** It was found that the factors (tooth type, gender and biotype) were also related to shorter lengths for the teeth, indicating that they may play a role in contributing to short clinical crowns and a diagnosis of altered passive eruption. The mean length of the mandibular teeth in the study was 8.18 mm and second premolars were shorter than this (average premolar length was 7.04 mm). For gender, females had an average clinical crown length of 7.79 mm, which was significantly shorter than their male counterparts (8.44 mm). Biotype was also shown to have a significant association with clinical tooth length. Teeth with a thick biotype were also found to be significantly shorter (7.86 mm) than teeth with a thin biotype (8.37 mm) (Table 2**)**.

When recession was examined on a tooth by tooth basis, it was found that the first premolar had the highest mean amount of recession at 0.11 mm. The lateral incisor had the lowest mean amount of recession at 0.02 mm **(**Table 9**)**. When the amount of attached tissue was examined for these same teeth, the mean value for the first premolar was 2.30 mm, while the mean amount for the lateral incisor was 3.33 mm (Table 9). When the prevalence of recession was viewed on a tooth by tooth basis, 11% of first premolars had recession, 10% of the second premolars had recession, 4% of the centrals had recession, 5% percent of the cuspids had recession and 1% of the laterals had recession.

When thin and thick biotype were analyzed according to presence of recession or mean amount of attached tissue present, on a tooth by tooth basis, it was found that for the central incisor, the presence of a thin biotype yielded a mean amount of recession of 0.11 mm. Alternatively, there was 0.00 mm of recession in patients with a thick mandibular central incisor biotype (Table 10**)**. For the central incisor, mean recession (repeated measure analysis of variance) and the presence of recession (logistic regression and Fisher's exact test) were significantly related to biotype ($P < 0.05$) (Table 10). No other tooth type was consistently related to recession by both statistical methods. For the first premolar, biotype was significantly related to mean recession only ($P < 0.05$). There was also a significant relationship between age and amount of keratinized tissue in the mandibular central incisors and laterals. This was a positive correlation and as age increased, the amount of attached, keratinized tissue increased as well ($P <0.05$) (Table10**)**.

When the variables effecting the width of attached gingiva were analyzed (evaluated by repeated measures analysis of variance) on a tooth by tooth basis, it was found that biotype had a significant effect on width of attached gingiva ($P<.0063$)in the central incisor, with a thick biotype having a mean width of 3.73 mm versus 2.66 mm for the thin biotype.

When the subjective documentation of appearance of gingival excess was compared to the width-to-length values for the individual teeth, it was found that if the subjective determination was made that gingival excess was present, the value for width-to-length ratio increased to significant levels (Table 11**)**. This was significant for all of the teeth being studied and the significance was greatest for the first premolar, second premolar and cuspid (all $P<.0001$), and less for the lateral ($P<.0087$) and central ($P<.01$).

Discussion

This study attempted to apply width-to-length proportions of teeth that are considered "ideal" (.80) in the maxillary arch to the mandibular teeth. In the maxillary arch, exceeding this ratio is a potential indicator of altered passive eruption and the prevalence of maxillary altered passive eruption is considered to have a detrimental effect on smile esthetics. The potential variables associated with this ratio were also analyzed in the mandibular arch. Because the mandibular teeth and their gingival zeniths are rarely visible upon smiling, the presence of mandibular altered passive eruption does not usually affect esthetics, as in the maxilla. The current study sought to determine whether gingival excess of the mandible may have some protective benefit from gingival insults which lead to recession development**.**

The results of the current study indicate that the average width-to-length ratio was 79.6%, which is consistent with the 80% threshold considered "ideal" in the maxilla for optimal esthetics. This proportion should be viewed with some caution, as there has never been a study to suggest that this is the optimal width-to-length ratio for mandibular teeth. Also, when the width-to-length ratios were examined for the individual teeth, there were a wide range of values from .99 for the mandibular second premolar to .67 for the mandibular central incisor (Table 3**)**. The mandibular centrals, laterals and canines were shown to have lower width-to-length ratios than premolars. This observation is best explained by their individual crown anatomies. The lengths of the mandibular centrals, laterals and canines are proportionally larger than their widths, according to data collected from extracted teeth by Wheeler[21] (Table 8). On the other hand, the lengths and widths of mandibular premolars are more similar and therefore yield a width-to-length proportion closer to 1 (Table 3**).** When the width-to-length ratios from Wheeler's study of extracted teeth without gingiva are compared to the values from the current study, the results are similar. The results were slightly higher for the current study, with variation in proportion due to presence of gingiva and variation in the dimension and biotype of the gingival tissue between subjects.

The variation in width-to-length values between Wheeler's extracted teeth and those of the current study were most likely due to a decrease in clinical crown length by the presence of gingiva. The anatomical crown length was shortened by the presence of connective tissue attachment, epithelial attachment and sulcus depth as proposed by Gargiulo[19]. The consequent decrease in crown length created a higher width-to-length ratio and a "gummier" appearance. The allowance for biologic width creates the shorter values for the lengths versus Wheeler's length data.

Subjects with a thick biotype were significantly more likely to have a width-to-length ratio of .80 or greater. These data are in agreement with that of De Rouck[14] who found that thicker biotypes did have a larger width-to-length ratio of .88 versus .79 for thin biotype. The current study found that thick biotypes had a mean width-to-length ratio of .85 and thin biotypes had a mean of .80 (Table 5**)**. Thicker biotype contributes to less crown exposure due to its larger degree of "biomass" which results in shorter crown lengths. This, in turn, leads to a larger width-to-length ratio.

Females had a significantly higher W:L ratio(Table 6) and this was due to a significantly shorter overall clinical tooth length versus males**.** The shorter the length of the tooth, the higher the W:L ratio. Tooth length, again, determined the W:L ratio.

The second premolar was also found to have a significantly larger width-to-length ratio of 1.02 (Table 7). This follows the trend of increasing width-to-length ratio from anterior teeth to posterior teeth that was reported in Wheeler's study (Table 5**).** His data showed a mean width-to-length ratio of .94. The finding from the current investigation is not surprising because the width and length of second premolar anatomical crowns in Wheeler's study are close to 1 without the presence of gingiva, as in Wheeler's study. When the gingiva is present, the cemento-enamel junction is often obscured by the free gingival margin. This decreases the clinical length and increases the width-to-length ratio.

The most interesting finding of this study was the high degree of agreement between the author's subjective determination of the appearance of gingival excess and a significant increase in width-to-length for all of the teeth being studied (Table 11**)**. Subjectively, 17% of the study subjects had gingival excess (Table 12**)**. Fourteen of these subjects had gingiva classified as thick and three classified as thin. For the subjective determination of gingival excess, the most frequently viewed teeth were the mandibular centrals, laterals and canines. The premolars are less visible from an anterior view and because of this, the mandibular centrals, laterals and canines are the predominant determinants in the appearance of gingival excess. The actual percentage of mandibular centrals with a width-to-length ratio greater than .80 was determined to be 9%. For the mandibular lateral incisors and canines, the values were 15% and 17 %, respectively. These values are very similar to the 17% deemed subjectively to have gingival excess. For the mandibular first premolar and second premolar, the percentages over the .80 width-to-length ratio were 78% and 92%, respectively. The importance of this finding is that it suggests that the eye of the examiner was capable of determining that there was an excess amount of gingiva present. This, in turn, provides some evidence that the threshold of .80 for defining the "ideal" amount of gingival display can be extrapolated to the mandibular arch from the maxillary study by Konikoff [20]. In all fairness, the sample size was small, and although the findings were significant, the question of whether or not mandibular gingival excess (APE) needs treatment is another matter.

Values above the .80 width-to-length threshold were used to identify, non-invasively, the presence of gingival excess. This measurement was not capable of leading to a diagnosis of altered passive eruption because the author did not identify where the crest of bone was relative to the CEJ. A true diagnosis of altered passive eruption would need to be confirmed by examination of radiographs and surgical exposure during crown-lengthening.

The real question is: at what point is gingival excess (APE) so unesthetic that it needs to be surgically corrected? This study does not address that question, but it does provide evidence that the .80 width-to-length ratio might hold some applicability in the mandibular arch for defining "ideal" (Table 11**)**. The current study determined that the mean width-to-length values for the mandibular centrals, laterals and canines are all close to the arbitrary value of .80. The .80 value was used as a starting point because ideal values don't currently exist for the mandible. The mean value was .75 for the central, .81 for the lateral and .78 for the canine for patients with thick biotype and the subjective appearance of no gingival excess. The mean values for the first and second premolars were .98 and 1.13, respectively. Within this study, a subjective absence of gingival excess was used to represent the ideal values. There was no statistically significant difference between biotypes for subjective appearance of gingival excess and W:L ratio. This data provides the first support for ideal values for width-to-length ratios for the mandibular anterior teeth.

The differences between the width-to-length values between anterior and posterior teeth can best be explained by differences in width-to-length ratio and tooth length. The anterior teeth, when compared to the posterior teeth, are longer **(**Table 3**)** and have a smaller width-to-length ratio. The findings of this study are supported by those of Ward[23], who conducted an online survey of dentists' preference for width-to-length ratios. He used an image of six maxillary anterior teeth and altered the lengths from very short to very tall. He also created different width-to-length ratios by altering the location of the gingival margin. The different width-to-length ratios examined were 62% (Golden Proportion), 70% and 80%. The preference for "ideal" by the dentists surveyed differed based on the shape of the tooth. The 62% was preferred for tall teeth, while the 80% value was preferred for very short/short teeth. The data from the current study seems to fit well with these proportions. The central mandibular incisor, which is longer than it is wide, had a width-to-length ratio of .67 for thick biotype and .63 for thin **(**Table 11**)** when the subjective appearance of gingival excess was not present. The lateral incisor and cuspid had similar values for width-to-length values **(**Table 11**)** and are also longer than they are wide. The premolars had an increase in width-to-length value and also have a **“**shorter” appearance. When it was felt that gingival excess was not present, the first premolar had a width-to-length ratio of .87 for thick and .85 for thin biotype **(**Table 11**).** The trend, therefore, within this study and that of Ward[23] is that anterior and posterior teeth have different shapes and therefore different ideal width-to-length ratios.

The differences in width-to-length ratio and subjective appearance of gingival excess suggest that there may not be one fixed width-to-length proportion that can be applied to all teeth in an arch. It follows then, that because the teeth within the mandibular arch have different shapes, they also have different ideal width-to-length proportions. This is the first data that puts forth preferences for ideal width-to-length values of mandibular teeth based on subjective appearance of gingival excess.

The question of when surgery becomes necessary to improve esthetics might best be answered by a combination of factors rather than a single proportion. The subjective feeling for presence of gingival excess, comparison of width-to-length values to “ideal” values and clinical documentation of variables such as location of CEJ in relation to bone height, probing depth and amount of incisal wear present may all help to determine the necessity for surgical intervention. This study can’t answer the question with any certainty in terms of whether or not there is one “ideal” width-to-length ratio that must be achieved for mandibular esthetics. What can be taken from this study is that the ideal is different for every tooth, depending on factors such as tooth shape and location in the arch.

In terms of the question of whether or not APE provides protection from gingival insult, the data seems to suggest that a patient with APE is not likely to have recession. However, within the study there were subjects that did exhibit recession. In order to determine what variables may have contributed to recession, logistic regression was performed. The association between the amount of attached keratinized tissue, amount of recession and probing depth were also evaluated. It was determined that a thin mandibular central incisor biotype was significantly more likely to have recession (Table 10**)** versus a thick biotype. The prevalence of recession in this study was lower than that documented in previous studies such as Thomson's examination of a birth cohort of 26 year-olds. Thomson[24] found that 70% of the population had at least 1 mm of recession. The prevalence in this current study was most likely lower because only 10 teeth were examined. If the entire dentition had been examined, the prevalence would most likely have increased. Note that the prevalence of recession was low, most likely due to the mean age of the study population at 25.91 years of age. Thus, these results must be viewed with some caution.

Over time, one would also expect the percentage of recession to increase within this population. A longitudinal, prospective study design that follows subjects with a thin biotype over time would provide the strongest evidence of that. Because of the cross-sectional nature of the current study, little predictive value as to the future development of recession in the patients identified as having a thin biotype can be placed on the data.

Conclusion

The Mean age of the study population was 25.91 years of age. The lengths of teeth were shorter than Wheeler's[21] extracted teeth due to presence of gingiva. The average width-to-length ratio was 79.6% for the subject population

Subjects with a thick biotype were significantly more likely to have a width-to-length ratio of .80 or greater ($p<0.0081$). Females had a significantly higher width-to-length ratio ($p<0.0237$) versus males. In terms of tooth type, the second premolar was also found to have a significantly larger width-to-length ratio of 1.02 ($p<0.0001$) versus the other teeth. The lengths of the teeth were also significantly related to biotype, gender and tooth type. Width of the teeth was only significantly related to tooth type.

For the central incisor, mean recession and the presence of recession were significantly related to biotype ($P < 0.05$). For the first premolar, biotype was significantly related to mean recession only ($P < 0.05$). Biotype had a significant effect on width of attached gingiva in the central incisor ($P<.0063$), with a thick biotype having a mean width of 3.73 mm versus 2.66 mm for the thin biotype. Biotype also had a significant effect for attached gingival width of the lateral incisor, with thick biotype having a mean width of 3.81mm and thin 2.95 mm.

Subjectively**,** 17% of the study subjects had gingival excess. When the author (WB) made the determination that gingival excess was present, there was a significant increase in the W:L ratio for all teeth, regardless of biotype.

Tables

Table 1. Distribution of subject Demographic Variables: Gender, Race, History of Orthodontic Treatment, Presence of Parafunctional Habits, Presence of Incisal and Occlusal Wear and Gingival Biotype

Gender	**N**	**Percentage**
Male	61	61%
Race		
African American	2	2%
Asian	16	16%
Caucasian	72	72%
Hispanic	4	4%
Other	6	6%
Orthodontic Treatment		
Yes	61	61%
Parafunctional Habits		
Yes	67	67%
Occlusal/Incisal Wear		
Yes	95	95%
Biotype		
Thick	60	60%
Thin	40	40%

Table 2. Periodontal Measurements and Indices according to Tooth Type: Pocket Depth (PD), Clinical Attachment Loss (CAL), Bleeding on Probing (BOP), Periodontal Index (PI), Gingival Index(GI)

	2nd Premolar		1st premolar		Canine		Lateral Incisor		Central Incisor	
	Mean	SD	**Mean**	SD	**Mean**	SD	**Mean**	SD	**Mean**	SD
PD (mm)	1.31	0.51	**1.30**	0.50	**1.23**	0.46	**1.23**	0.45	**1.16**	0.39
CAL (mm)	**0.21**	0.60	**0.27**	0.69	**0.17**	0.72	**0.07**	0.32	**0.12**	0.46
BOP	**0.01**	0.11	**0.02**	0.14	**0.02**	0.15	**0.02**	0.15	**0.02**	0.15
PI	**0.37**	0.55	**0.58**	0.68	**0.82**	0.76	**0.78**	0.75	**0.86**	0.80
GI	**0.23**	0.43	**0.35**	0.49	**0.54**	0.57	**0.61**	0.59	**0.58**	0.57

Table 3. Cast Measurements: Width, Length, W:L , Percent over ideal W:L Ratio of .80

	2nd Premolar		1st premolar		Canine		Lateral Incisor		Central Incisor	
	Mean	SD	**Mean**	SD	**Mean**	SD	**Mean**	SD	**Mean**	SD
Width (mm)	**6.94**	0.64	**7.06**	0.55	**6.73**	0.47	**5.84**	0.47	**5.26**	0.46
Length (mm)	**7.10**	0.83	**8.09**	0.80	**9.45**	1.19	**8.24**	0.94	**8.01**	0.98
W:L	**0.99**	0.16	**0.88**	0.10	**0.72**	0.10	**0.72**	0.10	**0.67**	0.12
Percent over ideal W:L of .80	**0.92**	0.28	**0.78**	0.42	**0.17**	0.37	**0.15**	0.35	**0.09**	0.28

Table 4. Significance of effect of variables on W:L , Width and Length

	W:L		**Width**		**Length**	
Age	0.6285		0.2112		0.6648	
Occlusal wear	0.7403		0.3552		0.2898	
Parafunction	0.8173		0.0816		0.1210	
Orthodontics	0.4844		0.7672		0.5429	
Gender	*0.0237		0.0709		0.0001	
Tooth Type	*<0.0001		<0.0001		<0.0001	
Race	0.3077		0.1557		0.2065	
Symmetry	0.2520		0.8592		0.1675	
Biotype	*0.0081		0.8892		0.0007	

Table 5. Effect of Biotype on W:L Ratio

Level	**Least Sq Mean**	**Std Error**
THICK	0.849	0.027
THIN	0.802	0.029

Table 6. Effect of gender on W:L Ratio

Level	Least Sq Mean	Std Error
F	0.84772144	0.02699896
M	0.80279039	0.03043470

Table 7. Effect of tooth type on W:L Ratio

Level	Least Sq Mean	Std Error
2nd Pre	1.02	0.028
1st Pre	0.91	0.028
Cuspid	0.75	0.028
Lateral	0.747	0.028
Central	0.697	0.028

Table 8. Wheeler's[21] Average W:L , Length, Width

Tooth	W:L Ratio	Cervico-Incisal/Occlusal Length of Crown (mm)	Mesiodistal Crown Diameter (mm)
Central Incisor	.56	9	5
Lateral Incisor	.58	9.5	5.5
Canine	.63	11	7
1st Premolar	.82	8.5	7
2nd Premolar	.94	8	7.5

Table 9. Gingival Parameters: Probing Depth, Clinical Attachment Level, Muco-gingival Width, Attached Tissue

		2nd-Pre	1st-Pre	Cuspid	Lateral	Central
Pocket Depth	N - Patients	100	100	100	100	100
	Mean	**1.31**	**1.30**	**1.23**	**1.23**	**1.16**
	Std Dev	0.51	0.50	0.46	0.45	0.39
Attachment level						
	Mean	**0.21**	**0.27**	**0.17**	**0.07**	**0.12**
	Std Dev	0.60	0.69	0.72	0.32	0.46
Recession						
	Mean	**0.08**	**0.11**	**0.10**	**0.02**	**0.05**
	Std Dev	0.32	0.40	0.52	0.16	0.25
Muco – gingival width	N	85	85	85	85	85
	Mean	**3.68**	**3.60**	**4.30**	**4.54**	**4.27**
	Std Dev	1.02	1.01	1.35	1.26	1.24
Keratinized-Attached	N - Patients	85	85	85	85	85
	Mean	**2.36**	**2.30**	**3.07**	**3.33**	**3.14**
	Std Dev	1.10	1.10	1.35	1.19	1.20

Table 10. Influence of Biotype on amount of Recession, Keratinized Tissue and Age

		2nd-Pre		1st -Pre		Cuspid		Lateral		Central	
	BIOTYPE_	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Recession	THICK	**0.05**	0.29	**0.07**	0.31	**0.08**	0.48	**0.00**	0.00	**0.00**	0.00
	THIN	**0.11**	0.36	$**0.16**	0.49	**0.13**	0.58	**0.04**	0.25	#**0.11**	0.39
Keratinized	THICK	**2.38**	1.17	**2.32**	1.12	**3.30**	1.29	***3.57**	1.13	***3.38**	1.18
	THIN	**2.33**	0.97	**2.26**	1.07	**2.71**	1.36	**2.96**	1.18	**2.75**	1.13
Age	THICK	**26.32**	3.02								
	THIN	**25.30**	3.00								

*Significantly related to biotype and age ($p < 0.05$). There was a positive correlation between age and keratinized tissue for the indicated teeth.

For the central incisor, mean recession (repeated measure analysis of variance) and the presence of recession (logistic regression and fisher's exact test) were significantly related to biotype ($p < 0.05$). No other tooth type was consistently related by both statistical methods.

$ For the first premolar biotype was significantly related to mean recession only ($p< 0.05$).

Table 11. Effect of Subjective Appearance of Gingival Excess on W:L Ratios for both thick and thin biotypes

			2nd -PRE			1ST-pRE			Cuspid			Lateral			Central		
BIOTYPE	APP G EXC		N	Mean	Std Dev	N	Mean	Std Dev	N	Mean	Std Dev	N	Mean	Std Dev	N	Mean	Std Dev
THICK	NO	W:l	46	**0.97**	0.13	46	**0.87**	0.09	46	**0.71**	0.09	46	**0.72**	0.12	46	**0.67**	0.14
	YES	W:l	14	**1.13**	0.25	14	**0.98**	0.09	14	**0.81**	0.09	14	**0.78**	0.07	14	**0.75**	0.05
THIN	NO	W:l	37	**0.96**	0.12	37	**0.85**	0.09	37	**0.69**	0.09	37	**0.69**	0.08	37	**0.63**	0.09
	YES	W:l	3	**1.12**	0.14	3	**1.00**	0.09	3	**0.81**	0.07	3	**0.78**	0.09	3	**0.67**	0.03

Figures

Figure1. Appearance of Mandibular Gingival Excess with thick Gingival Biotype

Figure 2. Recession of Gingival Tissue with thin Biotype

Figure 3. Normal Gingival Appearance with thin Biotype

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